
The Respiratory System

Anatomy, Physiology and Defense mechanisms of the respiratory tract

Respiratory System

Consists of the **respiratory** and **conducting** zones

- **Respiratory zone**

- Site of gas exchange
- Consists of bronchioles, alveolar ducts, and alveoli

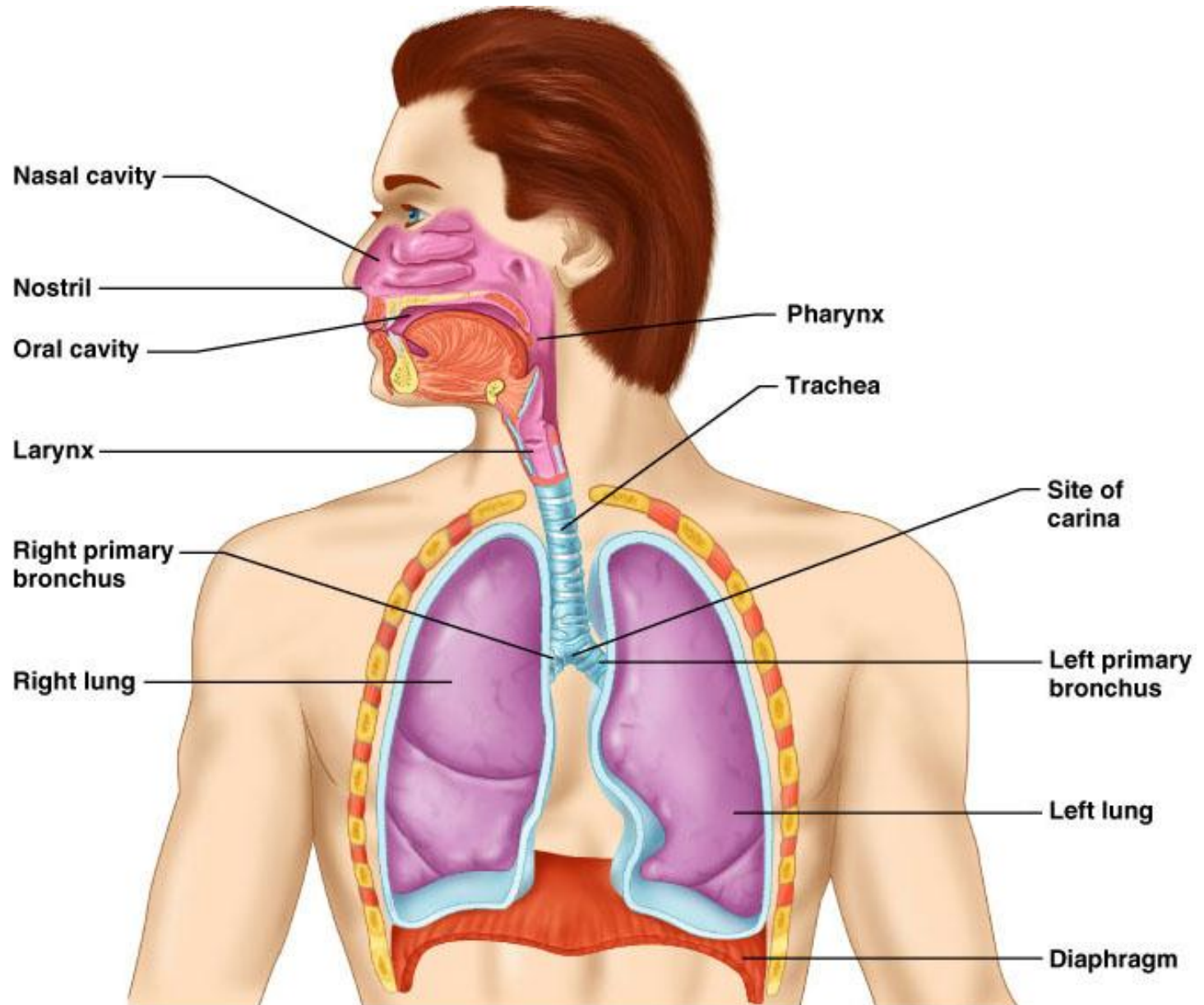
- **Conducting zone**

- Includes all other respiratory structures (e.g., nose, nasal cavity, pharynx, trachea)

Respiratory System

- **Respiratory muscles** – diaphragm and other muscles that promote ventilation

Respiratory System



Major Functions of the Respiratory System

To supply the body with oxygen and dispose of carbon dioxide

Respiration – four distinct processes must happen

- Pulmonary ventilation – moving air into and out of the lungs
- External respiration – gas exchange between the lungs and the blood
- Transport – transport of oxygen and carbon dioxide between the lungs and tissues
- Internal respiration – gas exchange between systemic blood vessels and tissues³

Function of the Nose

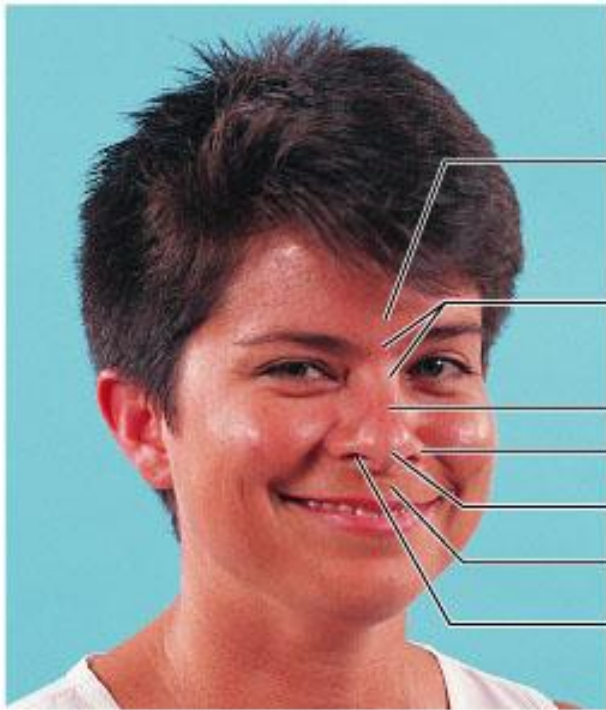
The only externally visible part of the respiratory system that functions by:

- Providing an airway for respiration
- Moistening and warming the entering air
- Filtering inspired air and cleaning it of foreign matter
- Housing the olfactory receptors

Nose

1. external portion

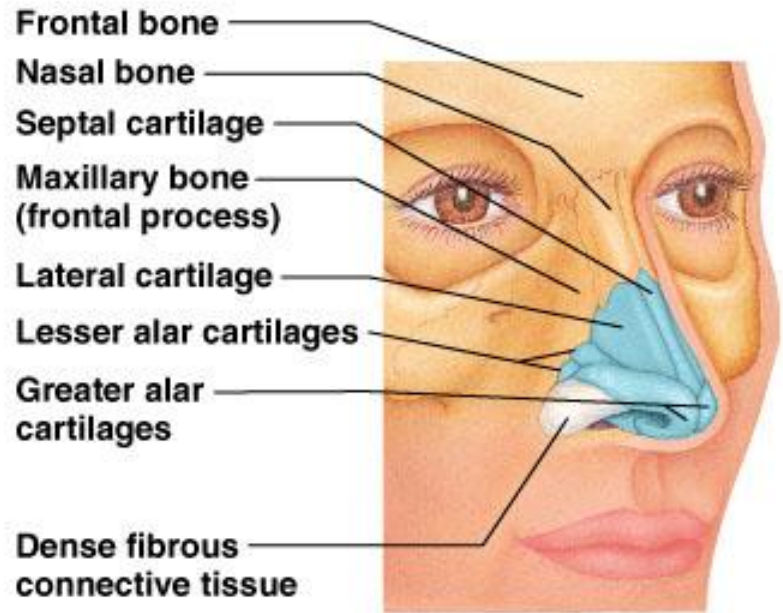
- a. mainly cartilage attached to nasal bones
- b. external nares (nostrils)
- c. vestibules - just inside external nares (put your finger)



- Frontalis muscle deep to skin
- Root and bridge of nose
- Dorsum nasi
- Ala of nose
- Apex of nose
- Philtrum
- External naris (nostril)

(a)

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- Frontal bone
- Nasal bone
- Septal cartilage
- Maxillary bone (frontal process)
- Lateral cartilage
- Lesser alar cartilages
- Greater alar cartilages
- Dense fibrous connective tissue

(b)

Nose

2. internal portion

- a. internal nares - connects nose to pharynx
- b. nasal septum - divides nasal cavity in two
- c. paranasal sinuses - cavities formed by cranium
 - i. frontal, sphenoidal, maxillary, ethmoidal
- d. meatuses - passageways formed by conchae
 - i. superior, middle, inferior
- e. olfactory region - above superior concha

Nasal Cavity

Respiratory mucosa

- Lines the balance of the nasal cavity
- Glands secrete mucus containing lysozyme to help destroy bacteria

Pharynx

Funnel-shaped tube of skeletal muscle that connects to the:

- Nasal cavity and mouth superiorly
- Larynx and esophagus inferiorly
- Extends from the base of the skull to the level of the sixth cervical vertebra

Pharynx

It is divided into three regions:

- **Nasopharynx**
- **Oropharynx**
- **Laryngopharynx**

Nasopharynx

- Lies posterior to the nasal cavity, inferior to the sphenoid, and superior to the level of the soft palate
- Strictly an air passageway
- Lined with pseudostratified columnar epithelium
- Closes during swallowing to prevent food from entering the nasal cavity
- The pharyngeal tonsil (adenoid) lies high on the posterior wall
- Pharyngotympanic (auditory) tubes open into the lateral walls

Oropharynx

- Extends inferiorly from the level of the soft palate to the epiglottis
- Serves as a common passageway for food and air
- The epithelial lining is protective stratified squamous epithelium
- Fauces - opening toward the mouth
- **Palatine tonsils**
- **Lingual tonsil**

Laryngopharynx

- Serves as a common passageway for food and air
- Lies posterior to the upright epiglottis
- Extends to the **larynx**, where the respiratory and digestive pathways diverge

Larynx (Voice Box)

- Attaches to the hyoid bone and opens into the **laryngopharynx** superiorly
- Continuous with the **trachea** posteriorly

Framework of the Larynx

1. Made up of 9 segments of cartilage:

a. **unpaired** - thyroid, epiglottic, cricoid

b. **paired** - arytenoid, corniculate, cuneiform

Larynx Cartilages

- thyroid cartilage (Adam's apple)
- epiglottis - covers larynx to route food
- **glottis** - vocal folds (cords) for sound
- cricoid cartilage - attaches larynx to trachea
- arytenoid cartilage - attached to vocal folds

Framework of the Larynx

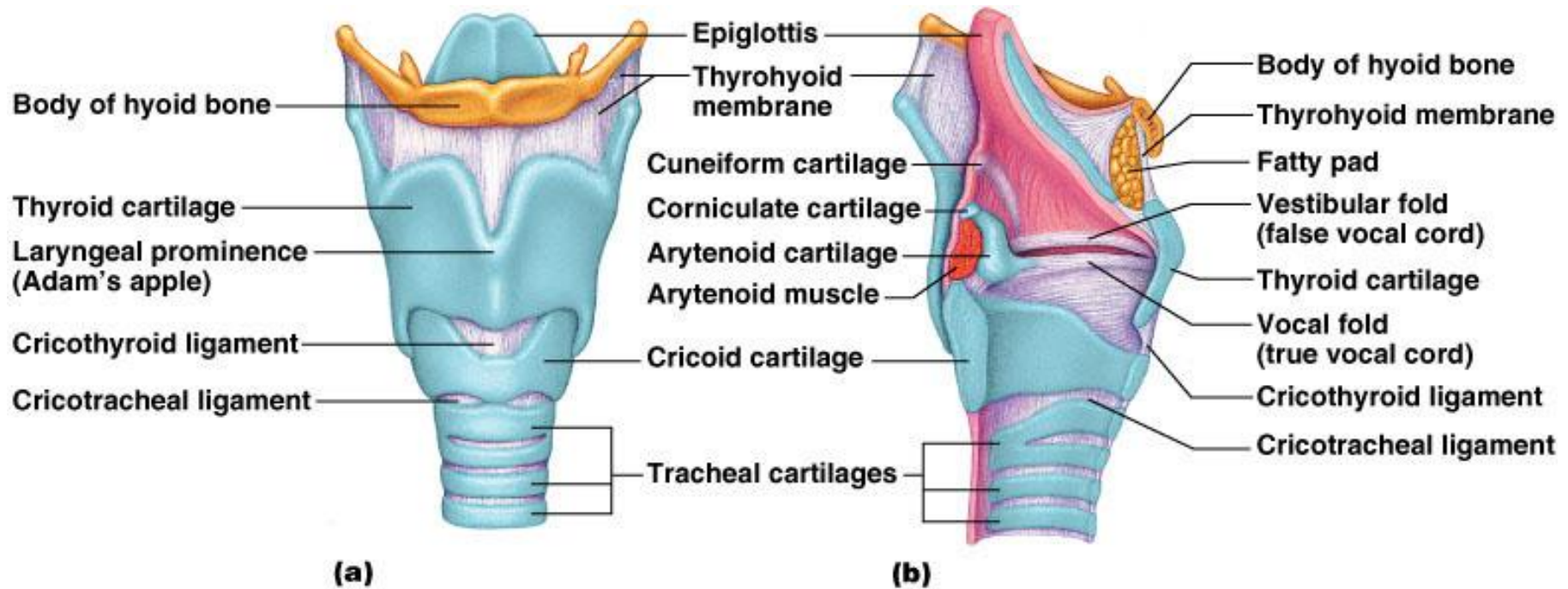


Figure 22.4a, b

Voice Production

a. **ventricular folds** (false cords)

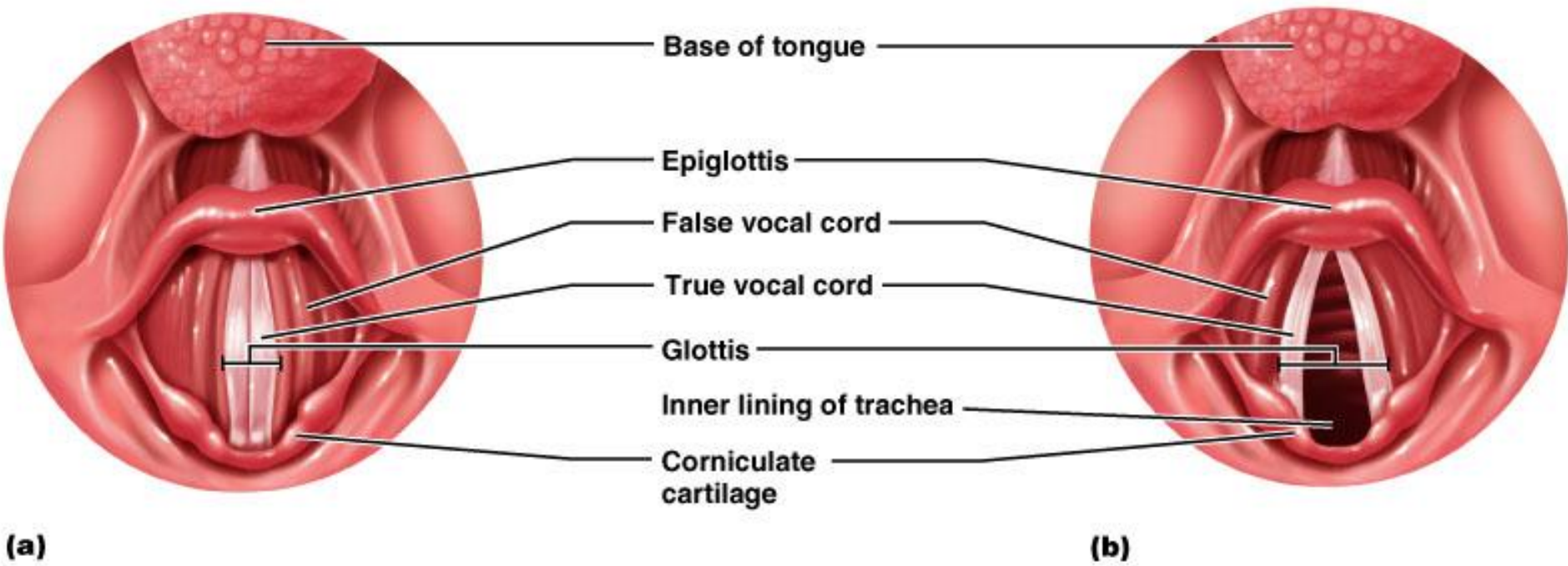
- hold breath against thoracic air pressure

b. **vocal cords** (true cords)

- vibrate to produce different frequencies

c. **pharynx, mouth, sinuses, nose, tongue, lips**

- alter the sound



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Trachea

1. larynx -> T5 ; anterior to the esophagus
2. C-shaped hyaline cartilage along the esophagus
3. carina - ridge at the bifurcation to the bronchi
4. intubation - tube down collapsed trachea
5. tracheostomy - hole in trachea; bypass obstructions

Trachea

- Mucosa – made up of goblet cells and ciliated epithelium
- Submucosa – connective tissue deep to the mucosa
- Adventitia – outermost layer made of C-shaped rings of hyaline cartilage

Trachea

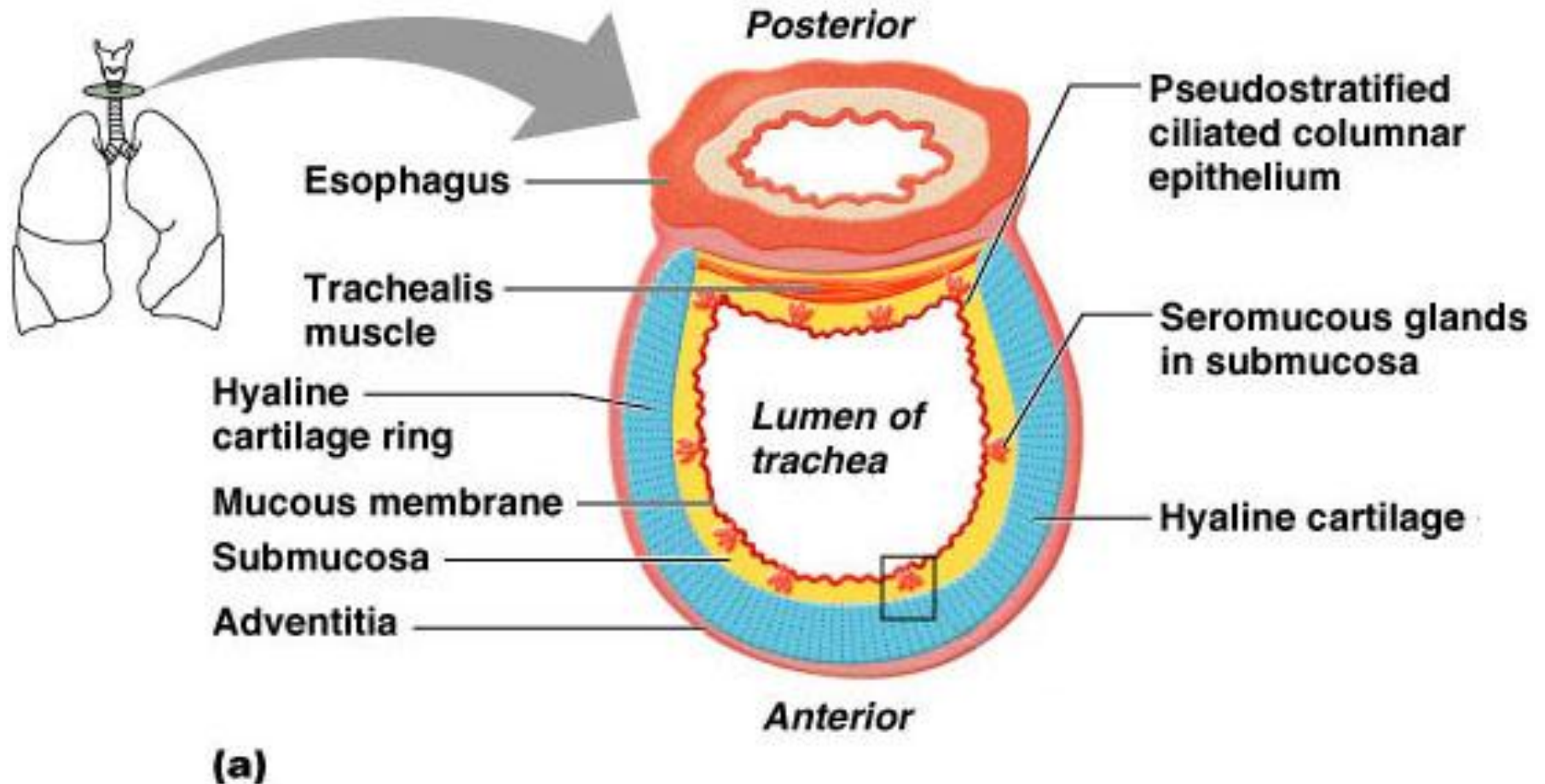


Figure 22.6a

Bronchi

Air reaching the bronchi is:

- Warmed and cleansed of impurities
- Saturated with water vapor
- Bronchi subdivide into secondary bronchi, each supplying a lobe of the lungs
- Air passages undergo 23 orders of branching in the lungs

Conducting Zone: Bronchial Tree

- Tissue walls of bronchi mimic that of the trachea
- As conducting tubes become smaller, structural changes occur:
 - Cartilage support structures change
 - Epithelium types change
 - Amount of smooth muscle increases

Bronchial Tree

Bronchioles:

- Consist of cuboidal epithelium
- Have a complete layer of circular smooth muscle
- Lack cartilage support and mucus-producing cells

Respiratory Zone

- Defined by the presence of **alveoli**; begins as terminal bronchioles feed into respiratory bronchioles
- Respiratory bronchioles lead to **alveolar ducts**, then to terminal clusters of alveolar sacs composed of alveoli
- Approximately 300 million alveoli:
 - Account for most of the lungs' volume
 - Provide tremendous surface area for gas exchange

Respiratory Zone

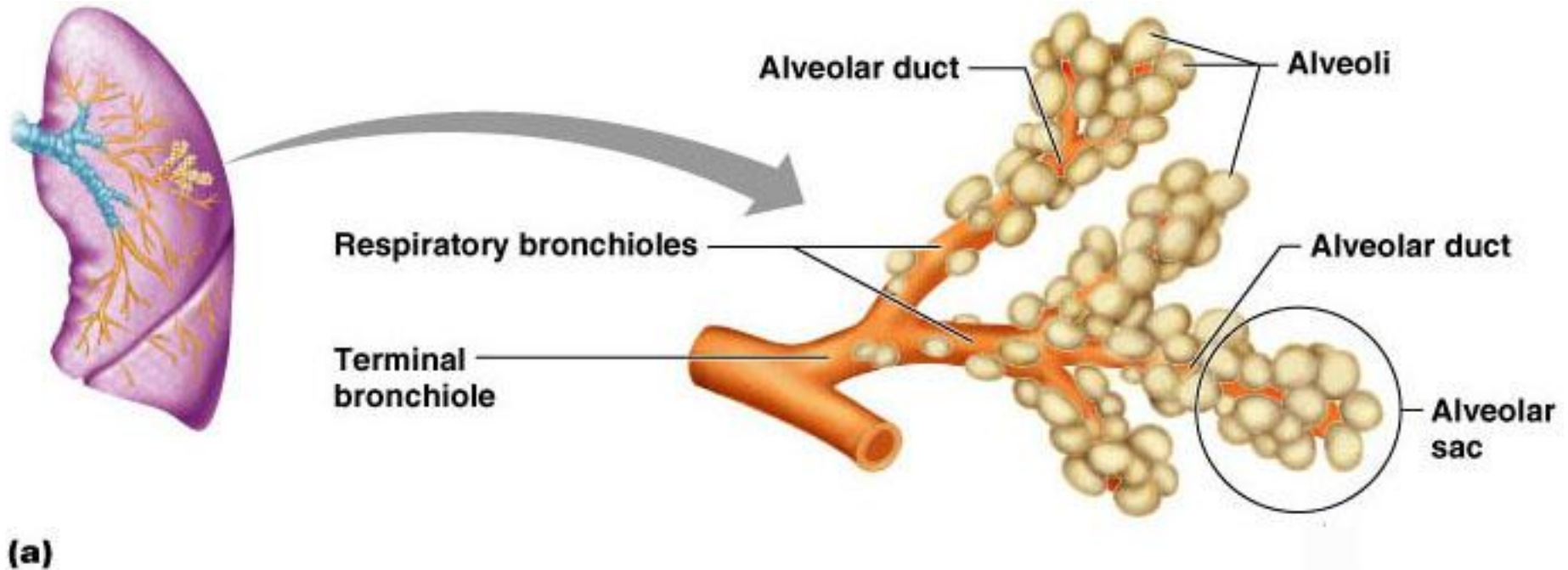
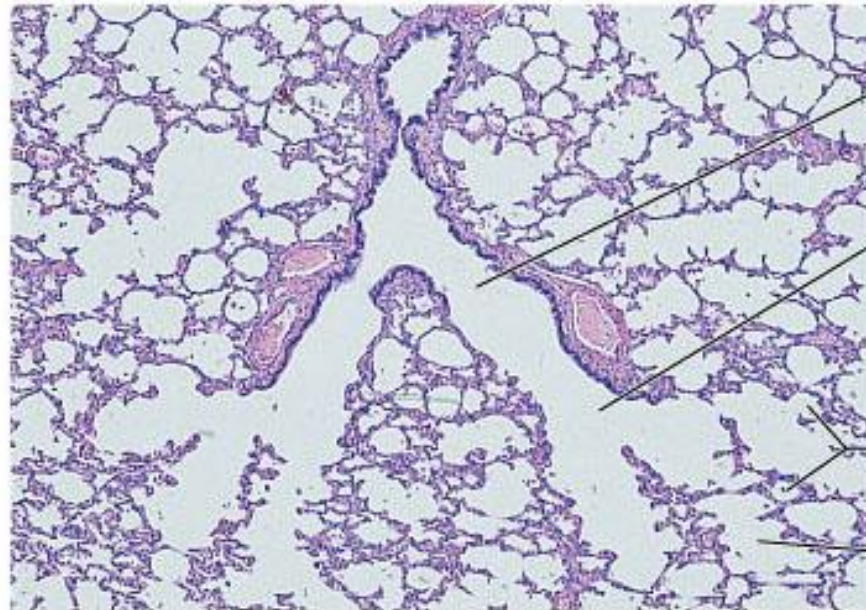


Figure 22.8a

Respiratory Zone



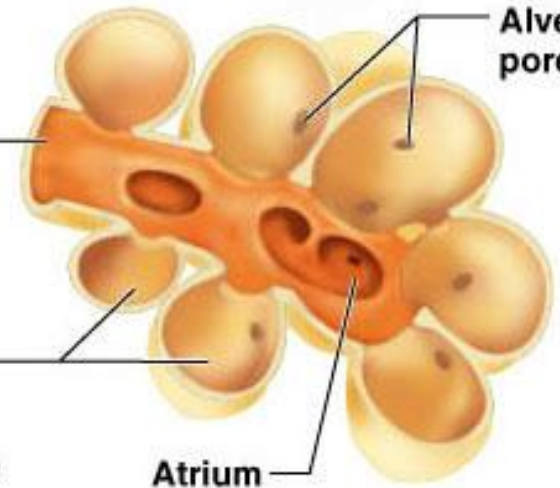
(b)

Respiratory
bronchiole

Alveolar
duct

Alveoli

Alveolar
sac

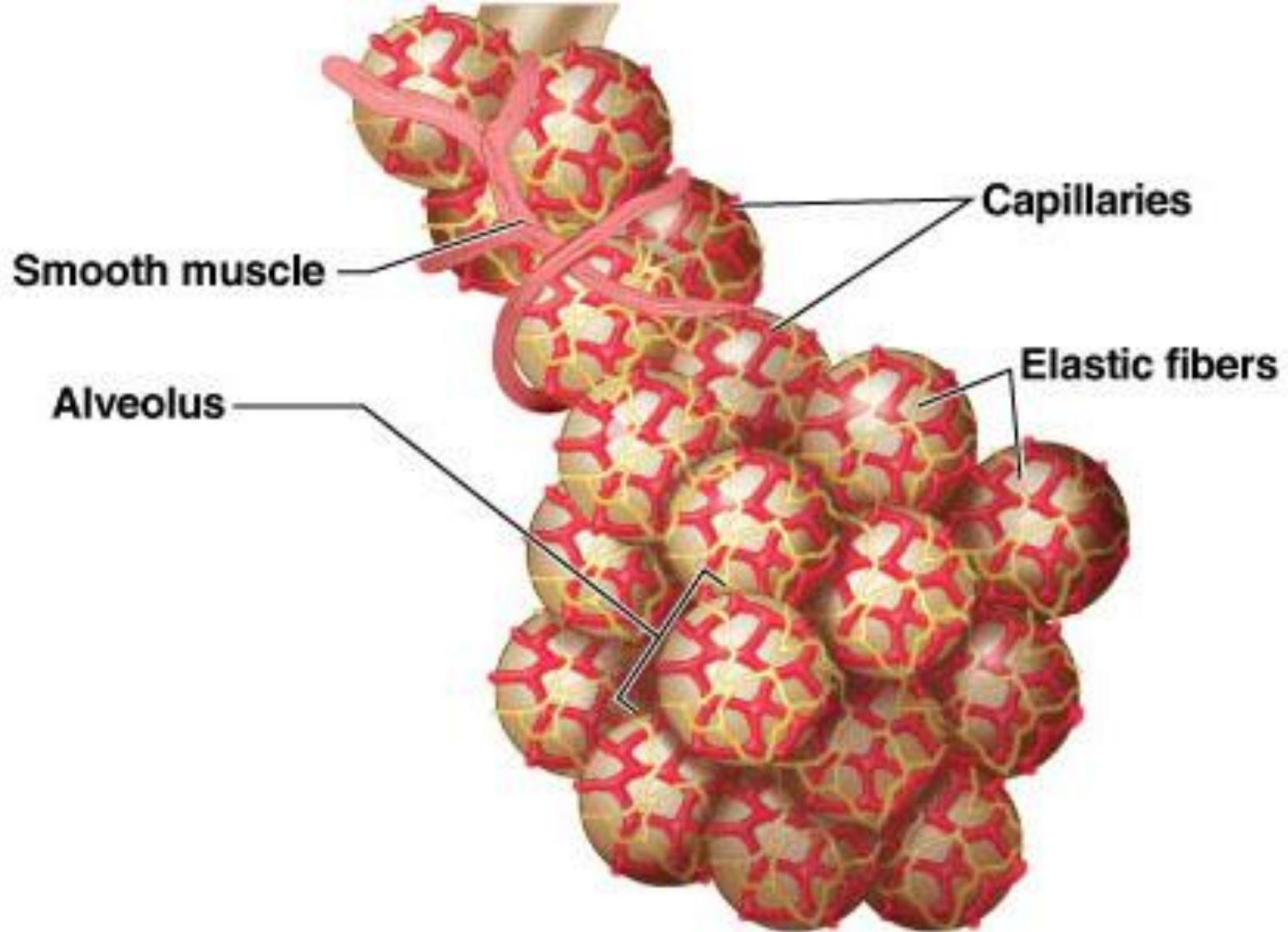


Alveolar
pores

Atrium

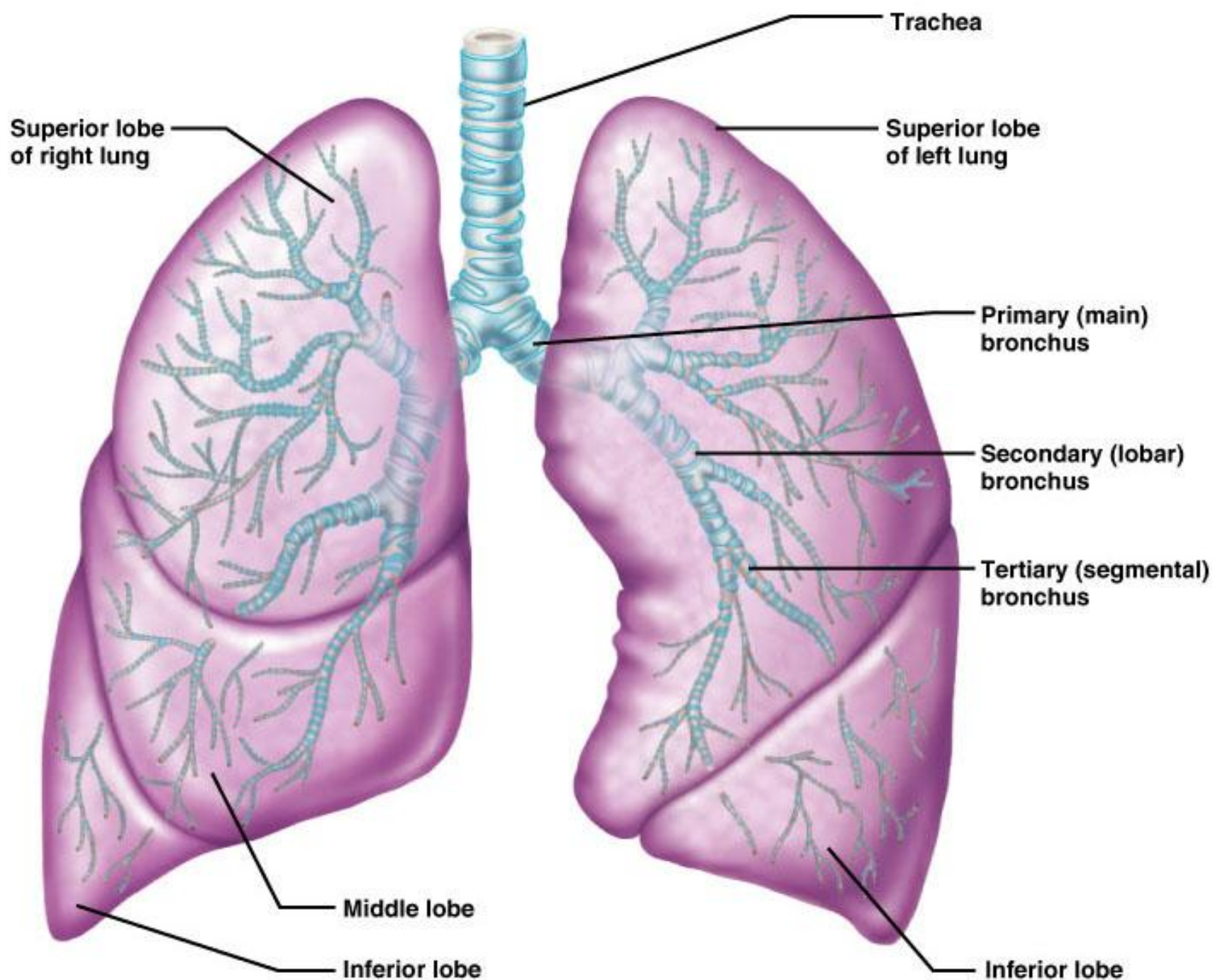
Figure 22.8b

Respiratory Membrane



Lungs

- **Cardiac notch (impression)** – cavity that accommodates the heart
- **Left lung** – separated into upper and lower lobes by the **oblique fissure**
- **Right lung** – separated into three lobes (superior, middle, inferior) by the **oblique and horizontal fissures**



Pleurae

Thin, double-layered serosa:

Parietal pleura

- Covers the thoracic wall and superior face of the diaphragm
- Continues around heart and between lungs

Visceral pleura

- Covers the external lung surface
- Divides the thoracic cavity into three chambers
 - The central mediastinum
 - Two lateral compartments, each containing a lung

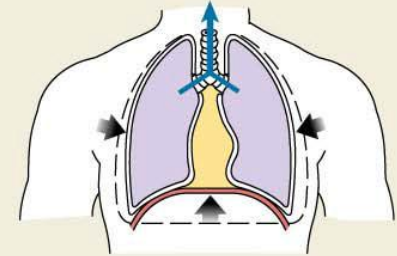
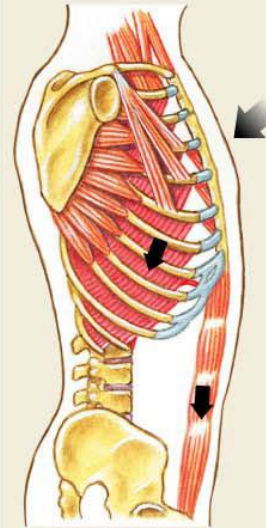
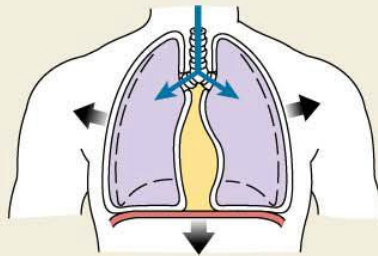
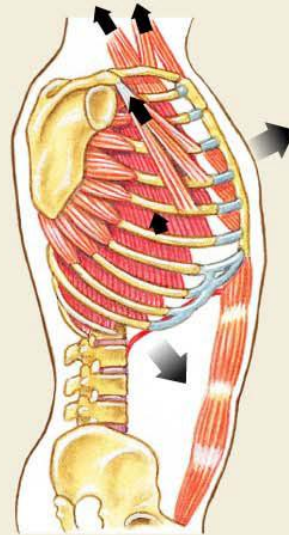
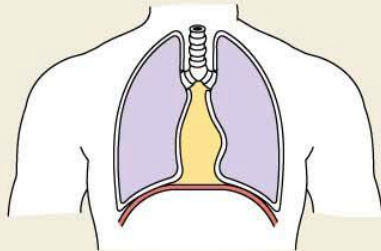
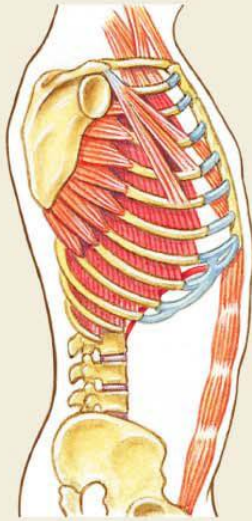
Pulmonary Ventilation

- Respiratory cycle—A single breath consisting of inspiration (inhalation) and expiration (exhalation)
- Respiratory rate—Number of cycles per minute
- Adult normal rate 12 to 18 breaths/minute
- Child normal rate 18 to 20 breaths/minute
- Alveolar ventilation—Movement of air into and out of the alveoli

Respiratory Physiology

■ Key Note

- The direction of air flow is determined by the relationship of atmospheric pressure and pressure inside the respiratory tract. Flow is always from higher to lower pressure



Respiratory Physiology

Gas Exchange

- External respiration—Diffusion of gases

between alveolar air and pulmonary capillary blood across the respiratory membrane

- Internal respiration—Diffusion of gases between blood and interstitial fluids across the capillary endothelium

Respiratory Physiology

Gas Transport

- Arterial blood entering peripheral capillaries delivers oxygen and removes carbon dioxide
- Gas reactions with blood are completely reversible
- In general, a small change in plasma PO_2 causes a large change in how much oxygen is bound to hemoglobin

■ Key Note

- Hemoglobin binds most of the oxygen in the bloodstream. If the PO_2 in plasma increases, hemoglobin binds more oxygen; if PO_2 decreases, hemoglobin releases oxygen. At a given PO_2 hemoglobin will release additional oxygen if the pH falls or the temperature rises.

Carbon Dioxide Transport

- Aerobic metabolism produces CO_2
- 7% travels dissolved in plasma
- 23% travels bound to hemoglobin Called carbaminohemoglobin
- 70% is converted to H_2CO_3 in RBCs Catalyzed by carbonic anhydrase Dissociates to H^+ and HCO_3^-

HCO_3^- enters plasma from RBCS

into bloodstream

plasma (as CO_2)

93% diffuses
into RBCs

23% binds to
Hb, forming
carbaminohemoglobin,
 $\text{Hb} \cdot \text{CO}_2$

70% converted
to H_2CO_3 by
carbonic anhydrase

H_2CO_3 dissociates
into H^+ and HCO_3^-

H^+ removed
by buffers,
especially

The Control of Respiration

■ Local Control of Respiration

Arterioles supplying pulmonary capillaries constrict when oxygen is low Bronchioles dilate when carbon dioxide is high

The Control of Respiration

Control by Brain Respiratory Centers

- Respiratory centers in brainstem
- Three pairs of nuclei
- Two pairs in pons
- One pair in medulla oblongata
- Control respiratory muscles
- Set rate and depth of ventilation
- Respiratory rhythmicity center in medulla

- Reflex Control of Respiration

- Inflation reflex

Protects lungs from overexpansion

- Deflation reflex

Stimulates inspiration when lungs collapse

- Chemoreceptor reflexes

Respond to changes in pH, PO₂, and PCO₂

in blood and CSF

Lung defences

- Upper airway defences
- Large airborne particles are trapped by nasal hairs, and smaller particles settling on the mucosa are cleared towards the oropharynx by the columnar ciliated epithelium which covers the turbinates and septum .
- During cough, expiratory muscle effort against a closed glottis results in high intrathoracic pressure, which is then released explosively.

Lung defences

- The flexible posterior tracheal wall is pushed inwards by the high surrounding pressure, which reduces tracheal cross-section and thus maximises the airspeed to achieve effective expectoration.
- The larynx also acts as a sphincter, protecting the airway during swallowing and vomiting

Lung defences

- Lower airway defences
- The sterility, structure and function of the lower airways are maintained by close cooperation between the innate and adaptive immune responses .
- The innate response in the lungs is characterised by a number of non-specific defence mechanisms.

Inhaled particulate matter is trapped in airway mucus and cleared by the mucociliary escalator. Cigarette smoke increases mucus secretion but reduces mucociliary clearance and predisposes towards lower respiratory tract infections, including pneumonia.

Lung defences

- Airway secretions contain an array of antimicrobial peptides (such as defensins, immunoglobulin A (IgA) antiproteinases and antioxidants. Many and **lysozyme**), assist with the opsonisation and killing of bacteria, and the regulation of the powerful proteolytic enzymes secreted by inflammatory cells. In particular, α 1- antiproteinase (A1Pi) regulates neutrophil elastase, and deficiency of this may be associated with premature emphysema.

Lung defences

- Macrophages engulf microbes, organic dusts and other particulate matter. They are unable to digest inorganic agents, such as asbestos or silica, which lead to their death and the release of powerful proteolytic enzymes that cause parenchymal damage.
- Neutrophil numbers in the airway are low, This may explain the prominence of lung injury in sepsis syndromes and trauma

Thank you